Phosphorene: A New High-Mobility 2D Semiconductor

HAN LIU, ADAM NEAL, Purdue University, ZHEN ZHU, DAVID TOMANEK, Michigan State University, PEIDE YE, Purdue University — The rise of 2D crystals has opened various possibilities for future electrical and optical applications. MoS$_2$ n-type transistors are showing great potential in ultra-scaled and low-power electronics. Here, we introduce phosphorene, a name we coined for 2D few-layer black phosphorus, a new 2D material with layered structure. We perform ab initio band structure calculations and show that the fundamental band gap depends sensitively on the number of layers. We observe transport behavior, which shows a mobility variation in the 2D plane. High on-current of 194 mA/mm, high hole mobility up to 286 cm$^2$/V·s and on/off ratio up to $10^4$ was achieved with phosphorene transistors at room temperature. Schottky barrier height at the metal/phosphorene interface was also measured as a function of temperature. We demonstrate a CMOS inverter with combination to MoS$_2$ NMOS transistors, which shows great potential for semiconducting 2D crystals in future electronic, optoelectronic and flexible electronic devices.